US009935456B2

(12) **United States Patent**
Mori et al.

(10) **Patent No.: US 9,935,456 B2**
(45) **Date of Patent: Apr. 3, 2018**

(54) **WIRELESS POWER TRANSMISSION DEVICE**

(71) Applicant: **TOKIN CORPORATION**, Sendai-shi, Miyagi (JP)

(72) Inventors: **Masashi Mori**, Sendai (JP); **Yuichi Sakurai**, Sendai (JP); **Kazumasa Makita**, Sendai (JP); **Koichi Mishina**, Sendai (JP); **Junetsu Urata**, Sendai (JP); **Yuichi Hosokawa**, Sendai (JP)

(73) Assignee: **TOKIN CORPORATION**, Miyagi (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 148 days.

(21) Appl. No.: **14/652,721**

(22) PCT Filed: **Mar. 7, 2014**

(86) PCT No.: **PCT/JP2014/056009**

§ 371 (c)(1),
(2) Date: **Jun. 16, 2015**

(87) PCT Pub. No.: **WO2014/156570**

PCT Pub. Date: **Oct. 2, 2014**

(65) **Prior Publication Data**

US 2016/0020600 A1 Jan. 21, 2016

(30) **Foreign Application Priority Data**

Mar. 28, 2013 (JP) 2013-067804

(51) **Int. Cl.**
H01F 38/14 (2006.01)
H02J 5/00 (2016.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H02H 7/20*** (2013.01); ***H02J 5/005*** (2013.01); ***H02J 7/025*** (2013.01); ***H02J 17/00*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H02H 7/20; H02J 50/10; H02J 50/12; H02J 50/80
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,421,409 B2 4/2013 Ichikawa
2011/0115303 A1* 5/2011 Baarman H02J 17/00 307/104
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2008206297 A 9/2008
JP 2011045045 A 3/2011
(Continued)

OTHER PUBLICATIONS

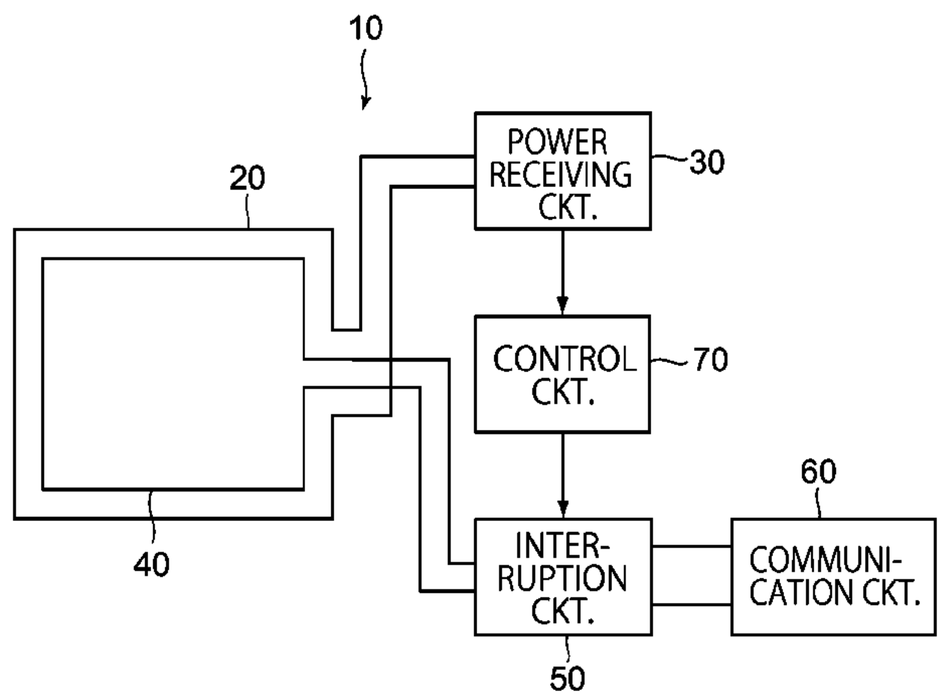
International Search Report (ISR) dated Apr. 28, 2014 issued in International Application No. PCT/JP2014/056009.
(Continued)

Primary Examiner — Jared Fureman
Assistant Examiner — Joel Barnett
(74) *Attorney, Agent, or Firm* — Holtz, Holtz & Volek PC

(57) **ABSTRACT**

A wireless power transmission device includes: a wireless power transmission unit, a power transmission circuit, a wireless communication unit, an interruption circuit, a communication circuit, and a control circuit. The power transmission circuit is connected to the wireless power transmission unit and wirelessly transmits power through the wireless power transmission unit to another party's device. The interruption circuit is connected to the wireless communication unit. The communication circuit is connected through the interruption circuit to the wireless communication unit and communicates with the other party's device via the wireless communication unit. The control circuit is connected to the power transmission circuit and the interruption circuit and, when the power is transmitted, controls the interruption circuit to interrupt between the wireless communication unit and the communication circuit on the basis of a power level transmitted by the power transmission circuit.

8 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

H02H 7/20	(2006.01)
H02J 7/02	(2016.01)
H02J 50/12	(2016.01)
H02J 17/00	(2006.01)
H03H 7/38	(2006.01)
H02J 50/05	(2016.01)

(52) **U.S. Cl.**
CPC ***H02J 50/12*** (2016.02); ***H03H 7/38*** (2013.01); *H01F 38/14* (2013.01); *H02J 50/05* (2016.02)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0278949	A1*	11/2011	Tsai	H02J 7/025 307/104
2011/0316475	A1*	12/2011	Jung	H02J 7/025 320/108
2012/0080957	A1*	4/2012	Cooper	H02J 5/005 307/104
2012/0146574	A1	6/2012	Ichikawa et al.	
2013/0270924	A1*	10/2013	Mori	H01F 38/14 307/104

FOREIGN PATENT DOCUMENTS

JP	2011172299	A	9/2011
JP	2012511892	A	5/2012
JP	2012530480	A	11/2012
WO	2010032309	A1	3/2010
WO	2012090904	A1	7/2012

OTHER PUBLICATIONS

Japanese Office Action dated Apr. 25, 2013 issued in counterpart Japanese Application No. 2013-067804.

* cited by examiner

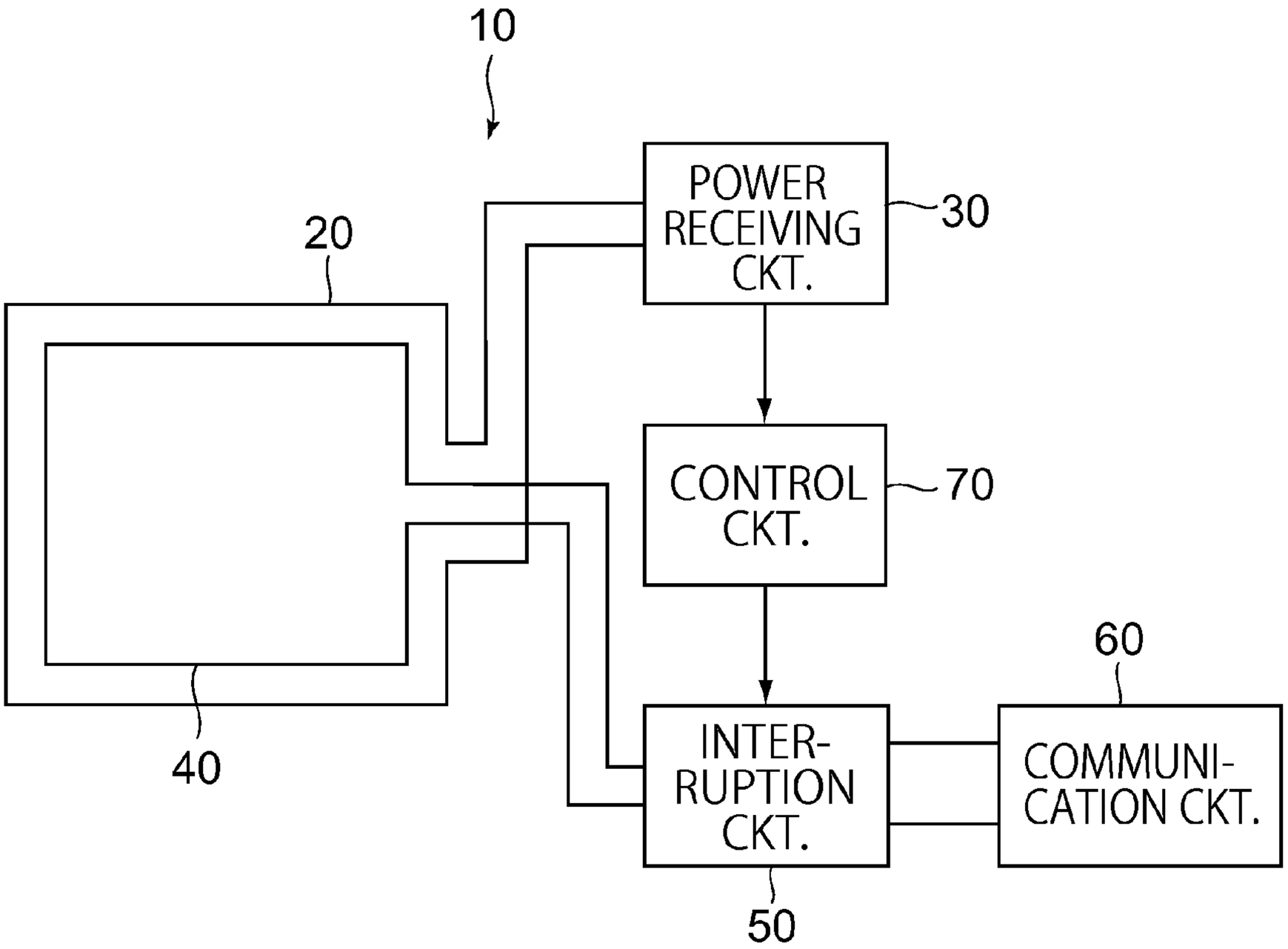

10
POWER RECEIVING CKT.
30
20
CONTROL CKT.
70
60
INTER-RUPTION CKT.
COMMUNI-CATION CKT.
40
50

FIG. 1

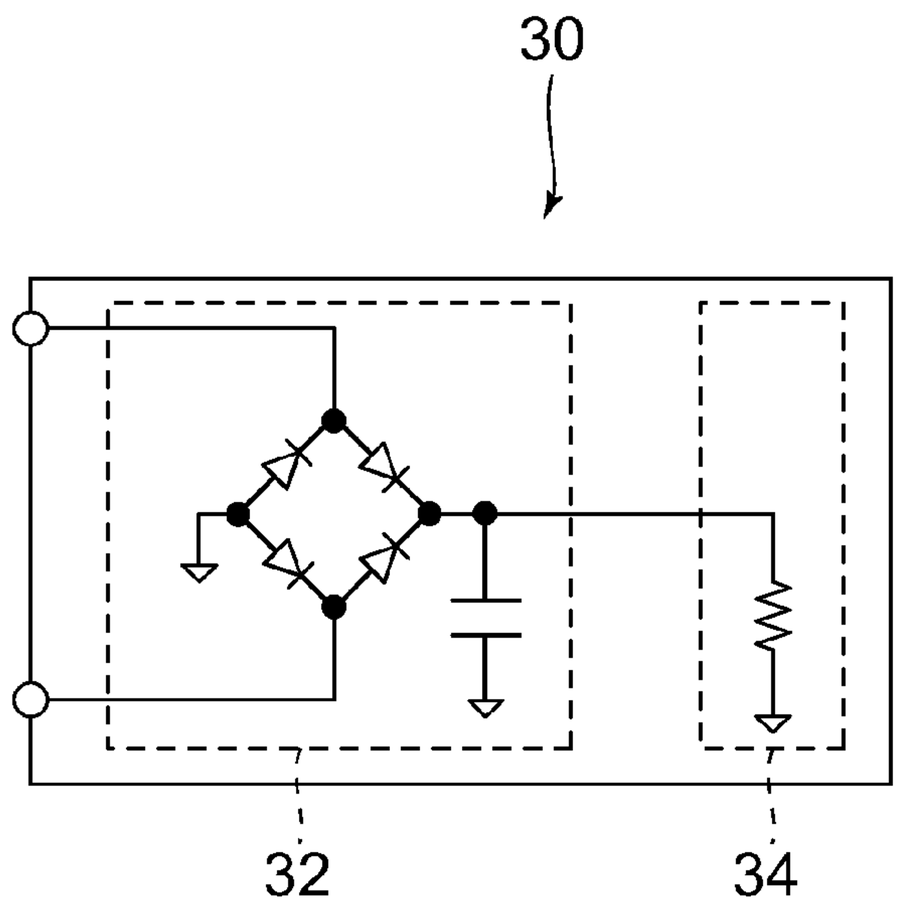

30
32
34

FIG. 2

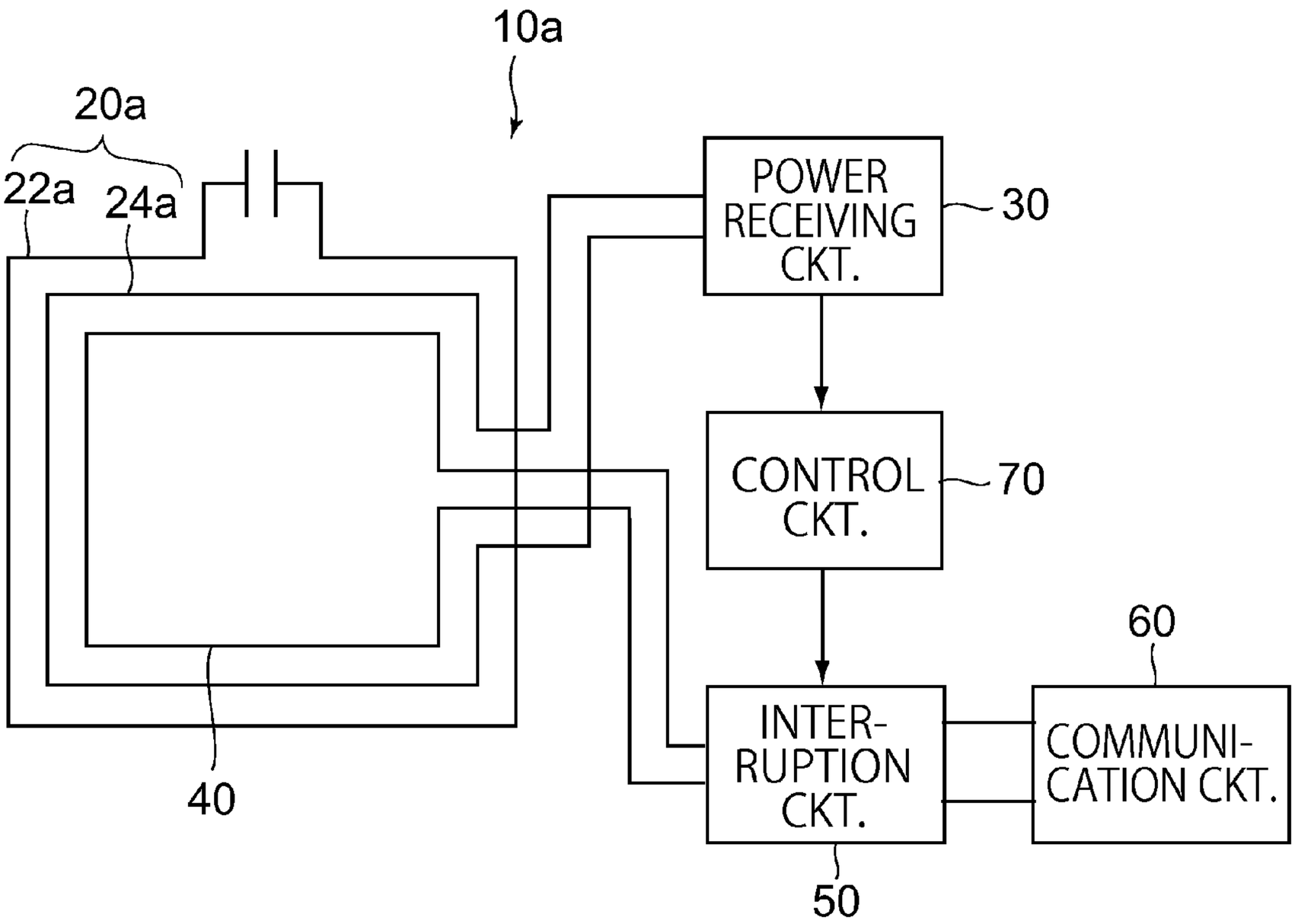

10a
20a
22a
24a
POWER RECEIVING CKT.
30
CONTROL CKT.
70
60
INTER-RUPTION CKT.
COMMUNI-CATION CKT.
40
50

FIG. 3

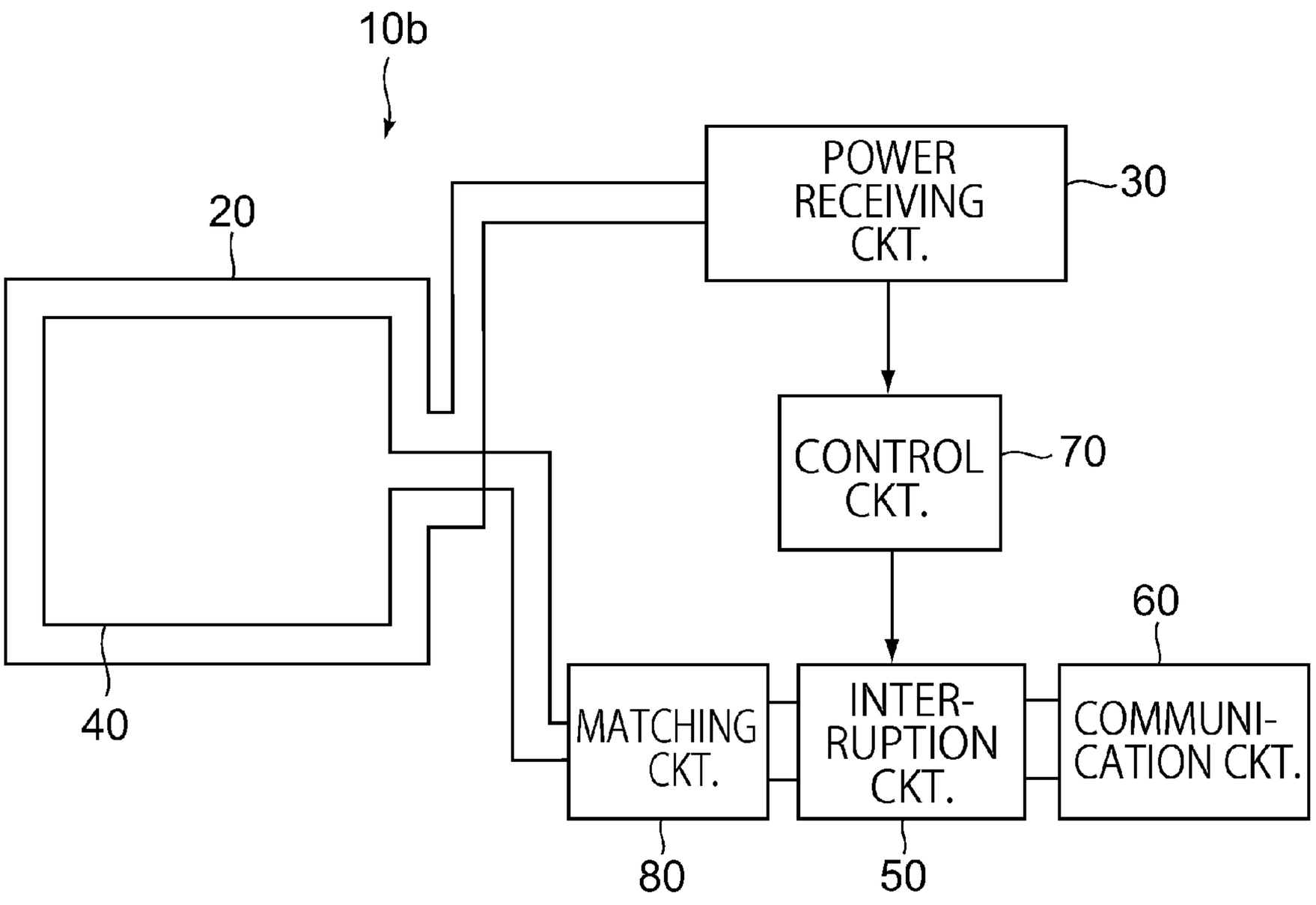

10b
20
POWER RECEIVING CKT.
30
CONTROL CKT.
70
60
40
MATCHING CKT.
INTER-RUPTION CKT.
COMMUNI-CATION CKT.
80
50

FIG. 4

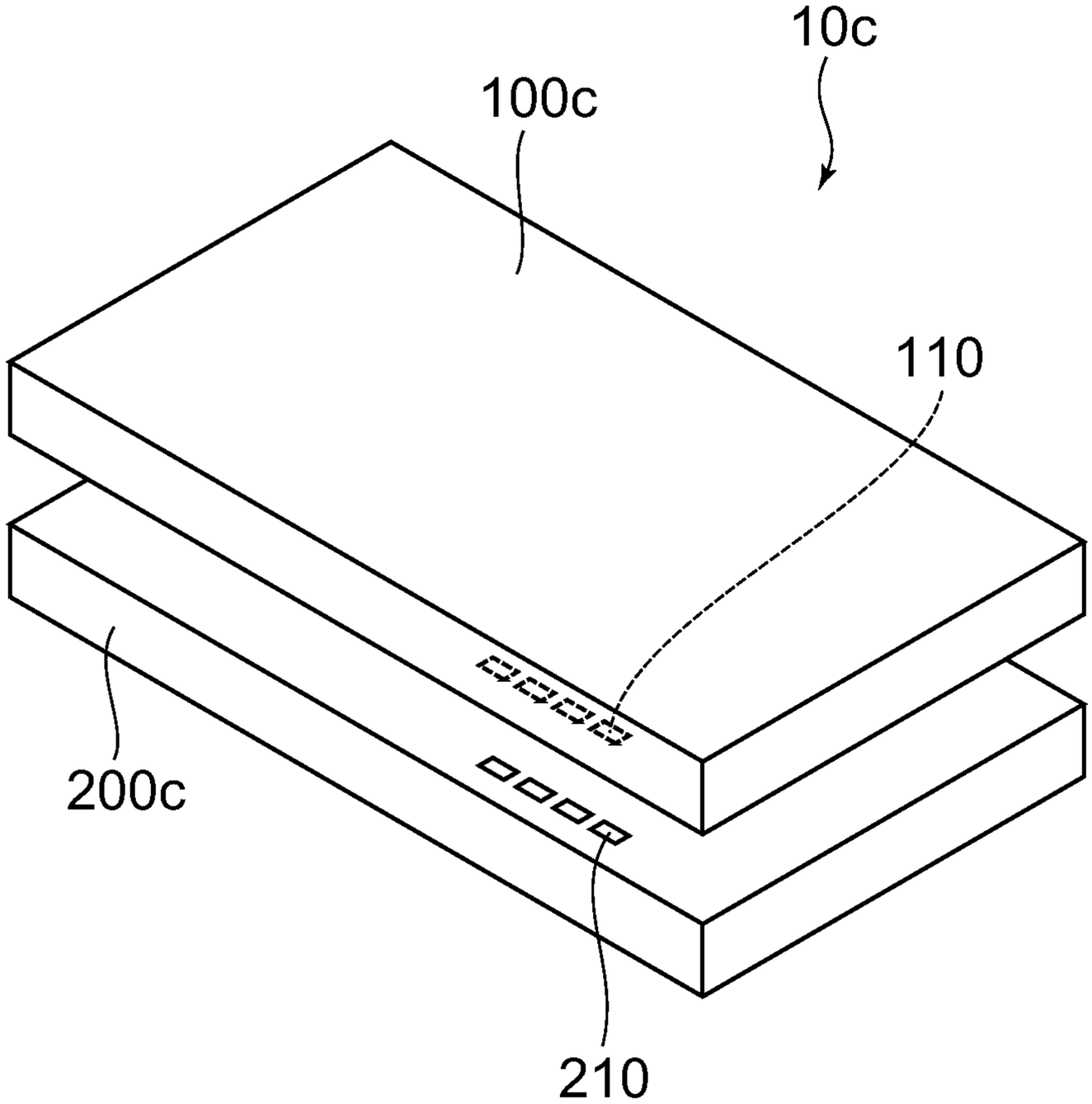


FIG. 5

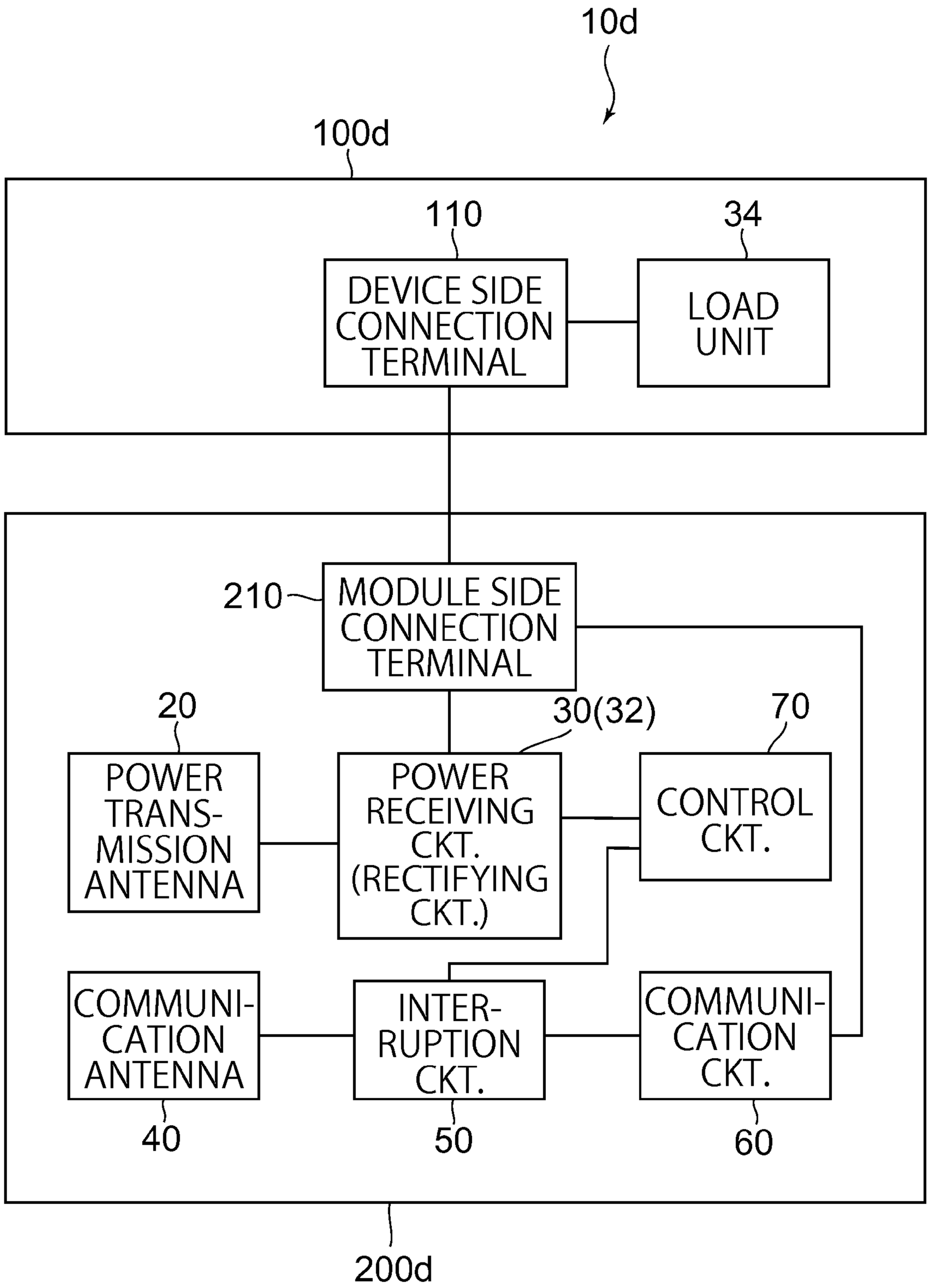

10d
100d
110
DEVICE SIDE CONNECTION TERMINAL
34
LOAD UNIT
210
MODULE SIDE CONNECTION TERMINAL
20
POWER TRANS-MISSION ANTENNA
30(32)
POWER RECEIVING CKT. (RECTIFYING CKT.)
70
CONTROL CKT.
COMMUNI-CATION ANTENNA
40
INTER-RUPTION CKT.
50
COMMUNI-CATION CKT.
60
200d

FIG. 6

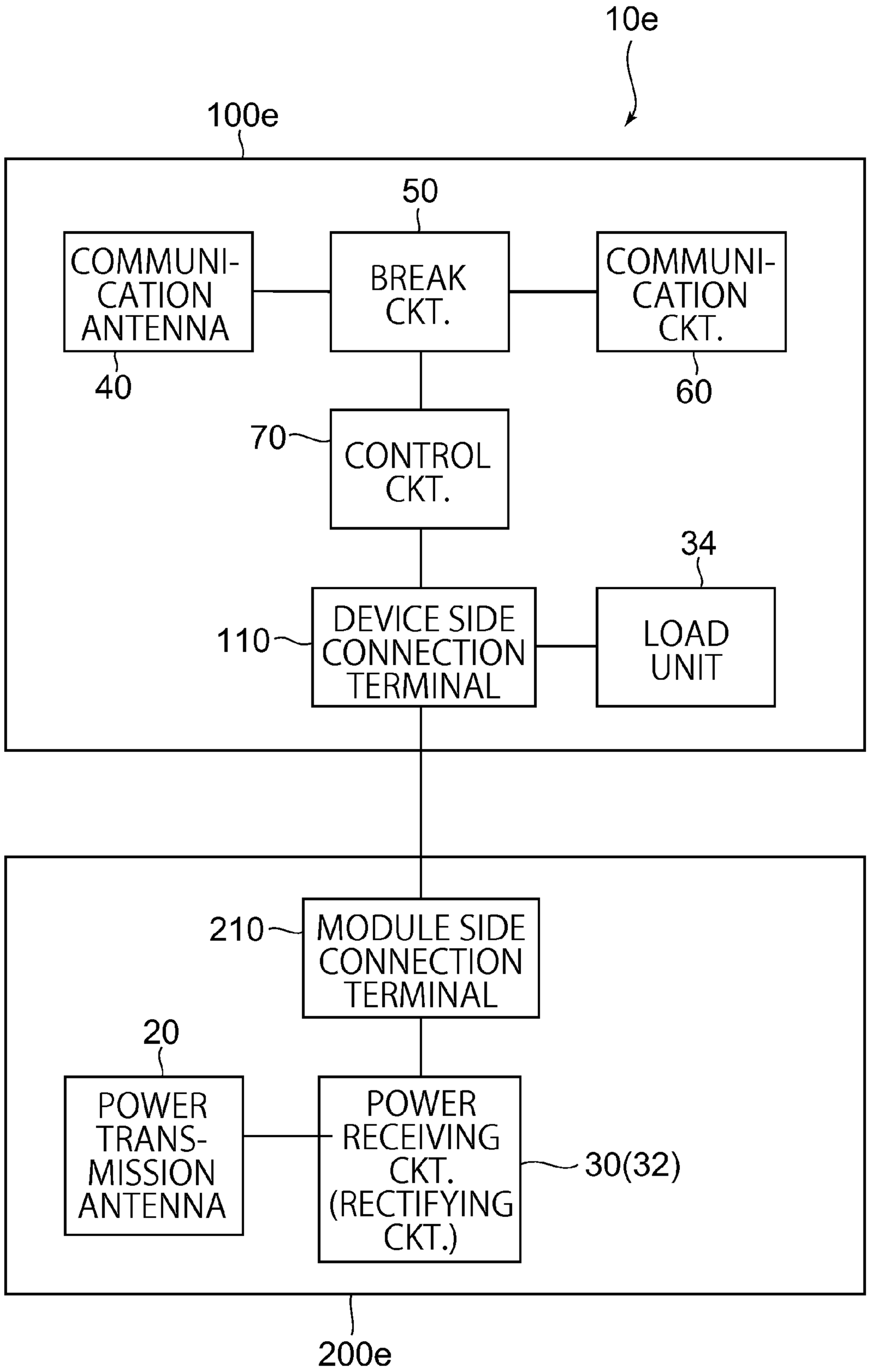

10e
100e
50
COMMUNI-CATION ANTENNA
40
BREAK CKT.
COMMUNI-CATION CKT.
60
70
CONTROL CKT.
34
110
DEVICE SIDE CONNECTION TERMINAL
LOAD UNIT
210
MODULE SIDE CONNECTION TERMINAL
20
POWER TRANS-MISSION ANTENNA
POWER RECEIVING CKT. (RECTIFYING CKT.)
30(32)
200e

FIG. 7

WIRELESS POWER TRANSMISSION DEVICE

TECHNICAL FIELD

This invention relates to a device that communicates with the other party's device and transmits power in a wireless manner.

BACKGROUND ART

Devices of this type are disclosed, for example, in Patent Literature 1. Each of the devices of Patent Literature 1 is provided with a coil antenna that is used for both of communication and power transmission. A power transmission system used between devices of Patent Literature 1 is an electromagnetic induction system that transmits power from a coil antenna of a device of a power transmission side to a coil antenna of a device of a power receiving side using magnetic flux as a medium. Especially, a power receiving device of the Patent Literature 1 is provided with an input connection circuit between a coil antenna and a communication circuit. The input connection circuit varies voltage applied to the communication circuit according to voltage occurred on the coil antenna. Thereby, it is prevented to apply overvoltage to the communication circuit at the time of power transmission.

As another wireless power transmission system that uses a coil, a resonance system, which utilizes resonance of circuits including coils, is known for example. Furthermore, a system in which an electrode of a power transmission side and an electrode of a power receiving side are arranged in proximity to each other to execute power transmission therebetween using capacitive coupling is also known (See Patent Literature 2).

CITATION LIST

Patent Literature

[PLT1] Japanese Unexamined Patent Application Publication No. 2011-172299

[PLT2] Japanese Translation of PCT International Application Publication No. 2012-530480

SUMMARY OF INVENTION

Technical Problem

The device of Patent Literature 1 mentioned above has a problem that a signal level is reduced at the time of communication since the input connection circuit works also at the time of the communication.

It is therefore the present invention aims to provide a wireless power transmission device that can protect a communication circuit at the time of power transmission and avoid a reduction of a signal level at the time of the communication.

Solution to Problem

One aspect of the present invention provides a wireless power transmission device that is provided with a wireless power transmission unit, a power transmission circuit, a wireless communication unit, an interruption circuit, a communication circuit and a control circuit. The power transmission circuit is connected to the wireless power transmission unit and executes power transmission with another party's device through the wireless power transmission unit in a noncontact manner. The interruption circuit is connected to the wireless communication unit. The communication circuit is connected to the wireless communication unit through the interruption circuit and executes communication with the other party's device through the wireless communication unit. The control circuit is connected to the power transmission circuit and the interruption circuit and controls the interruption circuit to interrupt between the wireless communication unit and the communication circuit according to a power level transmitted by the power transmission circuit on an occasion of the power transmission.

Advantageous Effects of Invention

As described above, the control circuit according to the one aspect of the present invention controls the interruption circuit to interrupt between the wireless communication unit and the communication circuit, when the power is transmitted, on the basis of the power level transmitted by the power transmission circuit. Hence, the wireless power transmission device according to the one aspect of the present invention does not need a circuit such as the input connection circuit of Patent Literature 1. Therefore, it is possible to protect the communication circuit suitably at the time of the power transmission and avoid the reduction of the signal level at the time of the communication.

By considering the following description of best embodiments with referring to accompanying drawings, the objects of the present invention will be understood certainly and a structure thereof will be understood perfectly.

BRIEF DESCRIPTION OF DRAWINGS

[FIG. **1**] A block diagram schematically showing a wireless power transmission device according to a first embodiment of the present invention.

[FIG. **2**] A drawing schematically showing a power receiving circuit included in the wireless power transmission device of FIG. **1**.

[FIG. **3**] A block diagram schematically showing a wireless power transmission device according to a second embodiment of the present invention.

[FIG. **4**] A block diagram schematically showing a wireless power transmission device according to a third embodiment of the present invention.

[FIG. **5**] A drawing schematically showing a wireless power transmission device according to a fourth embodiment of the present invention.

[FIG. **6**] A block diagram schematically showing an example of the wireless power transmission device of FIG. **5**.

[FIG. **7**] A block diagram schematically showing a modified example of the wireless power transmission device of FIG. **6**.

DESCRIPTION OF EMBODIMENTS

Though the present invention can be realized in diverse modifications and various modes, detailed description will be made in the following about specific embodiments shown in drawings by way of example. The drawings and the embodiments do not limit the present invention into the specific modes disclosed herein while all modified

examples, equivalents and alternative examples, which can be made within a range specified by accompanying Claims, are included as its objects.

First Embodiment

A wireless power transmission device according to a first embodiment of the present invention is a power receiving device and is that which executes wireless power transmission and communication with a power transmission device to be the other party's device.

As shown in FIG. **1**, a wireless power transmission device **10** is provided with a power transmission antenna (a wireless power transmission unit) **20**, a power receiving circuit (a power transmission circuit) **30** connected to the power transmission antenna **20**, a communication antenna (a wireless communication unit) **40**, an interruption circuit **50** connected to the communication antenna **40**, a communication circuit **60** connected to the communication antenna **40** though the interruption circuit **50**, and a control circuit **70** connected to the power receiving circuit **30** and the interruption circuit **50**.

Though the illustrated power transmission antenna **20** is that which consists of a loop antenna, it may be that which consists of a coil antenna.

The power receiving circuit **30** is that which executes power transmission through the power transmission antenna **20** together with the other party's device (not shown) in a wireless manner. A power transmission system according to the present embodiment is an electromagnetic induction system that transmits power using magnetic flux as a medium between the antenna and an antenna of the other party's device (not shown).

Especially, the illustrated power receiving circuit **30** is that which executes power receiving of power transmitted from the power transmission device (not shown), which is the other party's device, in a wireless manner. The power receiving circuit **30** according to the present embodiment is provided with, as shown in FIG. **2**, a rectifying circuit **32** connected to the power transmission antenna **20**, and a load unit **34**. The illustrated rectifying circuit **32** has a full wave rectifying circuit and a smoothing capacitor. However, the present invention is not limited thereto and various rectifying circuits may be used.

The load unit **34** according to the present embodiment, specifically, consists of a battery body and a protection circuit. Input impedance of the load unit **34** is high when the battery body is in a nearly full charged state or when the protection circuit is working. On the other hand, the input impedance of the load unit **34** is low when the battery body is in nearly empty state and the protection circuit is not working (i.e. in charging). Thus, the input impedance of the load unit **34** according to the present embodiment is varied.

Though the communication antenna **40** is that which consists of a loop antenna as shown in FIG. **1**, it may be that which consists of a coil antenna. The communication antenna **40** according to the present embodiment is surrounded by the power transmission antenna **20**. In the case of such an arrangement pattern, though space-saving is achieved in a whole of the wireless power transmission device **10**, a coupling coefficient between the power antenna **20** and the communication antenna **40** is increased and hence necessity to protect the communication circuit **60** from the power transmission is increased. Even where the power transmission **20** is surrounded by the communication antenna **40** as opposed to the present embodiment, necessity to protect the communication circuit **60** from the power transmission is high for the similar reasons. In these cases, protection of the communication circuit **60** which is described later and made by the control circuit **70** and the interruption circuit **50** according to the present embodiment is particularly effective.

The interruption circuit **50** interrupts between the communication antenna **40** and the communication circuit **60** under control of the control circuit **70** and oppositely cancels the interruption (i.e. connects). The interruption circuit **50**, for example, consists of a semiconductor switch or a mechanical switch.

The communication circuit **60** executes communication with the other party's device (not shown) through the communication antenna **40**. It should be noted that, on the occasion of the communication, the interruption by the interruption circuit **50** is cancelled as a matter of course. In the present embodiment, a frequency of power of the power transmission and a carrier wave frequency of the communication are different from each other. By differentiating the frequency of the power of the power transmission from the carrier wave frequency of the communication, it is also possible to interrupt AC power accompanied by the power transmission certainly by adding a band-pass filter or a resonant circuit to a system from the communication **40** to the communication circuit **60**. However, the present invention is not limited thereto and the frequency of the power of the power transmission and the carrier wave frequency of the communication may be the same in each other.

The control circuit **70** controls the interruption circuit **50** to interrupt between the communication antenna **40** and the communication circuit **60** in the occasion of the power transmission according to a power level received by the power receiving circuit **30** (i.e. a power level transmitted by the power transmission circuit). Specifically, the control circuit **70** according to the present embodiment decides that the power transmission is started according to that a transmitted power level exceeds a prescribed threshold value, and interrupts between the communication **40** and the communication **60** to protect the communication circuit **60** from the transmitted power. Because the control circuit **70** controls the interruption circuit **50** based on the level of the power transmitted in a power transmission system, unlike the case of Patent Literature 1, it is unnecessary to add an unnecessary impedance at the preceding stage of the communication circuit **60**. Therefore, according to the present embodiment, it is possible to avoid reduction of the signal level in the communication.

In detail, the control circuit **70** according to the present embodiment is that which conducts hysteresis control. That is, the control circuit **70** controls the interruption circuit **50** to interrupt between the communication antenna **40** and the communication circuit **60** when the level of the transmitted power is more than a first threshold value. On the other hand, the control circuit **70** controls the interruption circuit **50** to cancels the interruption when the level of the transmitted power is lower than a second threshold that is lower than the first threshold value.

Especially, the control circuit **70** according to the present embodiment controls the interruption circuit **50** based on an output of the rectifying circuit **32**. Specifically, the control circuit **70** controls the interruption circuit **50** to interrupt between the communication antenna **40** and the communication circuit **60** when the output (a voltage value of rectified power) of the rectifying circuit **32** is more than a first threshold value. On the other hand, the control circuit **70** controls the interruption circuit **50** to cancel the interruption

when the output of the rectifying circuit **32** is lower than a second threshold value that is lower than the first threshold value.

In the present embodiment, the first threshold value is decided based on a withstand voltage value of the communication circuit **60** while the second threshold value is decided based on a voltage value supplied to the load unit **34** when impedance of the load unit **34** is the minimum. When setting is made in this manner, the output of the rectifying circuit **32** exceeds the first threshold value at the time of start of power transmission and therefore protection for the communication circuit **60** is started appropriately. Moreover, even though charging for the battery of the load unit **34** is started and the output of the rectifying circuit **32** is temporarily reduced, the interruption by the interruption circuit **50** is continued and the communication circuit **60** is protected continuously. Furthermore, in a case where the power transmission is finished and the communication is started, because the output of the rectifying circuit **32** falls below the second threshold, the interruption by the interruption circuit **50** is cancelled and the communication circuit **60** is connected to the communication antenna **40** and thereby the communication is executed. Thus, according to the present embodiment, it is possible to appropriately protect the communication circuit **60** on the occasion of the power transmission.

It should be noted that the control by the control circuit **70** for the interruption circuit **50** is not limited to above. For example, the control circuit **70** may control the interruption circuit **50** so that the interruption circuit **50** interrupts between the communication antenna **40** and the communication circuit **60** according to a transmitted power level on the occasion of the power transmission and then the interruption circuit **50** cancels the interruption on the occasion of elapse a prescribed period. In the control, the control circuit **70** may measures the prescribed time. Besides, in the present embodiment, the control circuit **70** decides that the power transmission is started when the transmitted power level exceeds the prescribed level and controls the interruption circuit **50** to interrupt between the communication antenna **40** and the communication circuit **60**. However, the present invention is not limited thereto. For example, in a case where it is known that the power transmission is started after a lapse of a definite period of time from start of the communication, the control circuit **70** may control the interruption circuit **50** so that the interruption circuit **50** interrupts between the communication antenna **40** and the communication circuit **60** after counting a definite period of time from detecting start of the communication based on a power level.

Second Embodiment

Referring to FIG. **3**, a wireless power transmission device **10***a* according to a second embodiment of the present invention is a modified example of the wireless power transmission device **10** according to the first embodiment mentioned above. In FIG. **3**, the same components as the components of FIG. **1** are designated by the same reference numerals and detailed description for their components is omitted.

Though the power transmission system in the first embodiment mentioned above is the electromagnetic induction system, a power transmission system according to the present embodiment is a resonance system which uses a resonance field.

As shown in FIG. **3**, a power transmission antenna **20***a* of a wireless power transmission device **10***a* according to the present embodiment is provided with a resonance antenna **22***a* that can resonate with a prescribed frequency to accumulate power and a power transfer antenna **24***a* for taking out power accumulated in the resonance antenna **22***a*. The power transfer antenna **24***a* is connected to a power receiving circuit **30**. Other components are similar to those in the case of the first embodiment mentioned above.

Though the illustrated resonance antenna **22***a* and the power transfer antenna **24***a* are physically composed with different bodies, the resonance antenna **22***a* and the power transfer antenna **24***a* may share a part with each other. Besides, the power transfer antenna **24***a* may be omitted to take directly the power from the resonance antenna **22***a* by means of the power receiving circuit **30**. Furthermore, resonance may be also performed at a side of the power transfer antenna **24***a*.

Third Embodiment

Referring to FIG. **4**, a wireless power transmission device **10***b* according to a third embodiment of the present invention is a modified example of the wireless power transmission device **10** according to the first embodiment mentioned above. In FIG. **4**, the same components as the components of FIG. **1** are designated by the same reference numerals and detailed description for their components is omitted.

The wireless power transmission device **10***b* according to the present embodiment is further provided with a matching circuit **80** that connected between the communication antenna **40** and the interruption circuit **50** to match impedance of the communication antenna **40** with that of the communication circuit **60**.

In other words, the interruption circuit **50** according to the present embodiment is disposed between the matching circuit **80** and the communication circuit **60**. With such an arrangement, it is possible to give a margin to withstand voltage characteristics because a signal passing through the matching circuit **80** is suppressed in voltage width.

Fourth Embodiment

In FIG. **5**, an applied example of the wireless power transmission device according to above mentioned embodiments is shown. Referring to FIG. **5**, a wireless power transmission device **10***c* according to the present embodiment is provided with a portable electronic device **100***c* and a power transmission module **200***c*. The portable electronic device **100***c* is provided with a device side connection terminal **110** that consists of contacts while the power transmission module **200***c* is provided with a module side connection terminal **210** that consists of contacts. In the wireless power transmission device **10***c* according to the present invention, the device side connection terminals **110** and the module side connection terminals **210** are connected mutually by mounting the portable electronic device **100***c* on the power transmission module **200***c*. It should be noted that a connection form between the portable electronic device **100***c* and the electronic power transmission module **200***c* is not limited in this example. For example, the device side connection terminal **110** and the module side connection module **210** may be connectors and they may be connected with a cable.

In the portable electronic device **100***c*, at least the load unit **34** of components of the wireless power transmission devices according to the above mentioned embodiments is provided. On the other hand, in the power transmission module **200***c*, at least the power transmission antenna (wire-

less power transmission unit) **20** and the power receiving circuit (power transmission circuit) **30** (especially, the rectifying circuit **32**) of the components of the wireless power transmission devices according to the above mentioned embodiments are provided. Hereby, it is possible to add a wireless charging function to a portable electronic device **100***c* that does not have the wireless charging function.

An example in which the components of the wireless power transmission device **10** according to the above mentioned first embodiment is applied to the wireless power transmission device **10***c* according to the above mentioned fourth embodiment will be further described more concretely using FIGS. **6** and **7**.

In a wireless power transmission device **10***d*, only the load unit **34** of the components of the wireless power transmission device **10** according to the first embodiment is provided in a portable electronic device **100***d* while the other components are provided in a power transmission module **200***d*. In detail, in the portable electronic device **100***d*, the load unit **34** is connected to the device side connection terminal **110**. A power transmission module **200***d* is provided with the power transmission antenna **20**, the power receiving circuit **30** (the rectifying circuit **32**), the communication antenna **40**, the interruption circuit **50**, the communication circuit **60**, the control circuit **70** and the module side connection terminal **210** while the power receiving circuit **30** (the rectifying circuit **32**) and the communication circuit **60** are connected to the module side connection terminal **210**. Especially, in the case of this example, it is possible to add a wireless charge function to a conventional cellphone without modifying the conventional cellphone, for example.

In a wireless power transmission device **10***e* shown in FIG. **7**, only the power transmission antenna **20** and the power receiving circuit **30** (the rectifying circuit **32**) of the components of the wireless power transmission device **10** according to the first embodiment is provided in a power transmission module **200***e* while the other components are provided in a portable electronic device **100***e*. In detail, in the power transmission module **200***e*, the power circuit **30** (the rectifying circuit **32**) is connected to the module side connection terminal **210**. The portable electronic device **100***e* is provided with the load unit **34**, the communication antenna **40**, the interruption circuit **50**, the communication circuit **60** and control circuit **70** while the load unit **34** and the control circuit **70** are connected to the device side connection terminal **110**. Especially, in the case of this example, it is possible to protect the communication circuit **60** certainly because the communication antenna **40** is disposed away from the other party's device in comparison with the power transmission antenna **20**.

Modifications other than examples illustrated in FIGS. **6** and **7** are possible. For example, in the wireless power transmission device **10***d*, only the communication circuit **60** may be displaced to a side of the portable electronic device **100***d* to connect the communication circuit **60** with the device side connection terminal **110** and connect the interruption circuit **50** with the module side connection terminal **210**. In this case, a line connecting the power receiving circuit **30** with the load unit **34** and a line connecting the interruption circuit **50** and the communication circuit **60** are independent from each other. Furthermore, in the wireless power transmission device **10***e* shown in FIG. **7**, only the control circuit **70** may be displaced to a side of the power transmission module **200***e* to connect the power receiving circuit **30** with the control circuit **70** and connect the control circuit **70** with the module side connection terminal **210** and connect the interruption circuit **50** with the device side connection terminal **110**.

It should be noted that though the fourth embodiment is that which bases on the wireless power transmission device **10** according to the first embodiment, the present invention is not limited thereto. The wireless power transmission devices **10***a* and **10***b* according to the second and the third embodiments may be divided and put in the portable electronic device and the power transmission module as the fourth embodiment mentioned above.

Though the present invention has been described concretely with citing a plurality of embodiments, the present invention is not limited thereto and may be applied and modified.

For example, though the load unit **34** according to the embodiments mentioned above consists of the battery body and the protection circuit, the present invention is not limited thereto and it is applicable in a case of another load.

Furthermore, though the power transmission method in the embodiments mentioned above is the electromagnetic induction method or the resonance method, it may be a field coupling method or a capacitive coupling method. In such a case, the above mentioned wireless power transmission unit **20** and the above mentioned wireless communication unit **40** would be electrodes.

Moreover, though the power receiving device is the wireless power transmission device while the power transmission device is the other party's device in the above mentioned embodiments, the present invention is not limited thereto. Because it is necessary to protect a communication circuit from large power at a time of power transmission in a side of the power transmission device, a structure regarding protection for the communication circuit may be adapted in the side of the power transmission circuit in a case where it is not specified function or structure for the power receiving device. In such a case, that corresponding to the power receiving circuit in the power receiving device would be a power transmission circuit in the power transmission device. Accordingly, the control circuit would control the interruption circuit based on a power level transmitted by the power transmission circuit.

The present invention is based on Japanese Patent Application No. 2013-067804 filed on Mar. 28, 2013, and the contents of which forms a part of the present specification by reference.

While the best embodiments of the present invention have been described, as it is apparent to those skilled in the art, the embodiments are possible to be modified within a scope that is not departing from the spirit of the present invention, and such embodiments belong to the scope of the present invention.

REFERENCE SIGNS LIST

10, **10***a*, **10***b*, **10***c*, **10***d*, **10***e* wireless power transmission device

20, **20***a* power transmission antenna (wireless power transmission unit)

22*a* resonance antenna

24*a* power transferring antenna

30 power receiving circuit (power transmission circuit)

32 rectifying circuit

34 load unit

40 communication antenna (wireless communication unit)

50 interruption circuit

60 communication circuit
70 control circuit
80 matching circuit
100*ci*, **100***d*, **100***e* portable electronic device
110 device side connection terminal
200*c*, **200***de*, **200***e* power transmission module
210 module side connection terminal

The invention claimed is:

1. A wireless power receiving device comprising:

a wireless power receiving unit that comprises an antenna or an electrode to receive power in a wireless manner;

a power receiving circuit that is connected to the wireless power receiving unit and receives power transmitted from a power transmission device through the wireless power receiving unit in the wireless manner;

a wireless communication unit that comprises a communication antenna;

an interruption circuit that is connected to the wireless communication unit;

a communication circuit that is connected to the wireless communication unit through the interruption circuit and executes communication with the power transmission device through the wireless communication unit; and

a control circuit that is connected to the power receiving circuit and the interruption circuit and controls the interruption circuit to interrupt between the wireless communication unit and the communication circuit according to a power level received by the power receiving circuit on an occasion of the power receiving;

wherein:

the power receiving circuit comprises a rectifying circuit that rectifies power received through the wireless power receiving unit, and a load unit that receives rectified power from the rectifying circuit;

the control circuit controls the interruption circuit to interrupt between the wireless communication unit and the communication circuit when a voltage value of the rectified power is more than a first threshold value, and controls the interruption circuit to cancel the interruption when the voltage value of the rectified power is lower than a second threshold value that is lower than the first threshold value;

the load unit has a variable impedance;

the first threshold value is based on a withstand voltage value of the communication circuit; and

the second threshold value is based on a voltage value supplied to the load unit when the impedance of the load unit is equal to a minimum value.

2. The wireless power receiving device as recited in claim **1**, comprising a portable electronic device and a power receiving module, wherein:

the portable electronic device is provided with at least a device side connection terminal;

at least the load unit is provided in the portable electronic device;

the power receiving module is provided with at least a module side connection terminal;

at least the wireless power receiving unit and the power receiving circuit are provided in the power receiving module; and

the load unit and the power receiving circuit are connected to each other through the device side connection terminal and the module side connection terminal.

3. The wireless power receiving device as recited in claim **1**, further comprising a matching circuit that is connected between the wireless communication unit and the interruption circuit and executes impedance matching.

4. The wireless power receiving device as recited in claim **1**, wherein:

the wireless power receiving unit comprises a power receiving antenna consisting of a loop antenna or a coil antenna, and

the communication antenna consists of a loop antenna or a coil antenna.

5. The wireless power receiving device as recited in claim **4**, wherein one of the power receiving antenna and the communication antenna is provided to surround the other.

6. The wireless power receiving device as recited in claim **4**, wherein the power receiving antenna comprises a resonance antenna that executes power receiving with the power transmission device through a resonance field.

7. The wireless power receiving device as recited in claim **6**, wherein the power receiving antenna further comprises a power transferring antenna used for transferring power between the resonance antenna and the power receiving circuit.

8. The wireless power receiving device as recited in claim **1**, wherein a frequency of a power of the power receiving and a carrier wave frequency of the communication are different from each other.

* * * * *